

Section II (REMARKS)

Allowable Subject Matter

In the Office Action dated June 23, 2005, the Examiner indicated that claim 18 was objected to as being dependent upon a rejected base claim, but that claim 18 would be allowable if rewritten in independent form including all of the limitations of the base claim. Specifically, the Examiner stated that the closest prior art of record ... fails to specifically teach or suggest that the GaN (0001) surface is offcut from a <0001> direction towards a <1010> or <1120> direction at an offcut angle in a range of from about 5 to about 8 degrees. Applicant agrees with the Examiner's characterization of the prior art in this regard, but further posits that the prior art of record fails to teach or suggest greater offcut angles within the range of original claim 1; specifically, the prior art fails to teach or suggest that the GaN (0001) surface is offcut from a <0001> direction towards a <1010> or <1120> direction at an offcut angle in a range of from *about 5 to about 10 degrees*. Accordingly, amended claims 1, 22, 28, and 39 all include this offcut angle limitation in a range of from about 5 to about 10 degrees.

Request for Rejoinder of Non-Elected Method Claims

In the March 21, 2005 Office Action, the Examiner imposed a restriction requirement against claims 1-39 and required that an election be made between Group I (claims 1-21 and 39, drawn to a semiconductor substrate) and Group II (claims 22-38, drawn to a method of making a semiconductor substrate). Applicants elected Group I with traverse in a Response To Restriction Requirement filed on April 21, 2005.

In the June 23, 2005 Office Action, the Examiner made the restriction final, but indicated that he "will consider rejoinder under MPEP §821.04 at the time of determination of the allowability of all pending Group I claims, if the non-elected method claims are commensurate in scope with the allowable article claims." (June 23, 2005 Office Action, page 3.) **Because claim 1 is now drawn to allowable subject matter, Applicants hereby request rejoinder of non-elected method claims 22-38 pursuant to MPEP §821.04.** Amended method claims 22 and 28 are indeed

commensurate in scope with amended claim 1. Amended independent claim 1 (of the Group I claims) recites the following GaN structure:

1. A GaN substrate including a GaN (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in a range that is from about 5 to about 10 degrees, wherein said surface has a RMS roughness measured by $50 \times 50 \mu\text{m}^2$ AFM scan that is less than 1 nm, and a dislocation density that is less than $3\text{E}6 \text{ cm}^{-2}$. (Emphasis added.)

and amended independent claim 22 (of the group II claims) recites a method of forming such a GaN structure:

22. A method of forming a GaN substrate including a GaN (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in a range that is from about 5 to about 10 degrees, wherein said surface has a RMS roughness measured by $50 \times 50 \mu\text{m}^2$ AFM scan that is less than 1 nm, and a dislocation density that is less than $3\text{E}6 \text{ cm}^{-2}$, said method including growing a bulk GaN single crystal body, and processing said bulk GaN single crystal body to form at least one wafer therefrom, wherein said processing step includes a step selected from the group consisting of: (i) a slicing step conducted in a slicing plane tilted away from the c-plane at said offcut angle in said direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, (ii) an angle lapping step conducted in a lapping plane tilted away from the c-plane at said offcut angle in said direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, and (iii) separating said bulk GaN single crystal body after growing said bulk GaN single crystal body on a vicinal heteroepitaxial substrate including a (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in said range of from about 5 to about 10 degrees. (Emphasis added.)

while amended independent claim 28 (of the group II claims) recites another method of forming a GaN structure including substantially the same limitations:

28. A method of fabricating a microelectronic or opto-electronic device, comprising

- (a) forming a GaN substrate including a GaN (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in a range that is in a range of from about 5 to about 10 degrees, wherein said surface has a RMS roughness measured by 50 x 50 μ m AFM scan that is less than 1 nm, and a dislocation density that is less than 3E6 cm⁻², said method including growing a bulk GaN single crystal body, and processing said bulk GaN single crystal body to form at least one wafer therefrom, wherein said processing step includes a step selected from the group consisting of: (i) a slicing step conducted in a slicing plane tilted away from the c-plane at said offcut angle in said direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, (ii) an angle lapping step conducted in a lapping plane tilted away from the c-plane at said offcut angle in said direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, and (iii) separating said bulk GaN single crystal body after growing said bulk GaN single crystal body on a vicinal heteroepitaxial substrate including a (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in said range of from about 5 to about 10 degrees, and
- (b) depositing on said GaN substrate a homoepitaxial III-V nitride material.

Rejoinder is fully proper under these circumstances because all of the pending claims are directed to allowable subject matter and are in condition for allowance, and all of the limitations of amended claim 1 are contained in claims 22 and 28, such that all of these claims have commensurate scope.

Response to the §102 Rejections of Claims 1-6, 13, 15, 16, 19-21, and 39

In the June 23, 2005 Office Action, the Examiner rejected claims 1-6, 13, 15, 16, 19-21, and 39 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent Application Publication No. 2001/0030329 A1 to Ueta et al. (hereinafter "Ueta").

In response, Applicants have amended claims 1 and 39. Claims 4-6 have been cancelled herewith, so the rejections of those claims are moot.

Applicants respectfully traverse the Examiner's rejection of claims 1-4, 13, 15, 16, 19-21, and 39, due to the patentable distinctions of claims 1-6, 13, 15, 16, 19-21, and 39 over the Ueta reference.

Ueta discloses "a GaN substrate having a crystal orientation which is tilted away from a <0001> direction by an angle which is equal to or greater than about 0.05° and which is equal to or less than about 2°" (Ueta, ¶ 0013). In one embodiment according to Ueta, "the GaN substrate has a crystal orientation which is tilted away from a <0001> direction in a <11-20> or <1-100> direction."

By virtue of the amendments to independent claims 1, 22, 28, and 39, all of the pending claims now require, *inter alia*, a GaN (0001) surface offcut from the <0001> direction predominantly towards a direction selected from the group consisting of <10 $\bar{1}$ 0> and <11 $\bar{2}$ 0> directions, at an offcut angle in a range that is from **about 5 to about 10 degrees**. (Emphasis added.) The Examiner has already recognized that Ueta **"fails to specifically teach or suggest that the GaN (0001) surface is offcut from a <0001> direction towards a <1010> or <1120> direction at an offcut angle in a range of from about 5 to about 8 degrees."** (Emphasis added)(June 23, 2005 Office Action, page 6.) Ueta similarly fails to teach a GaN surface offcut from a <0001> direction towards a <1010> or <1120> direction at an offcut angle in a range of from about 5 to about 10 degrees. For at least this reason, all of claims 1-3, 13, 15, 16, 19-21, and 39 (which have the "about 5 to about 10 degrees" offcut limitation) are allowable over Ueta, and withdrawal of the 102(b) rejection of these claims is respectfully requested.

Response to the §103 Rejections of Claims 1-17, 19 and 39

In the June 23, 2005 Office Action, the Examiner rejected claims 1-17, 19 and 39 under 35 U.S.C. 103(a) as being obvious over Zauner et al., *Homo-epitaxial GaN growth on exact and misoriented single crystals: suppression of hillock formation*, J. Crystal Growth, 210 (2000), pp. 435-443 (hereinafter "Zauner").

In response, Applicants have amended claims 1 and 39. Claims 4-12 and 17 have been cancelled herewith, so the rejections of those claims are moot.

Applicants respectfully traverse the Examiner's rejection of claims 1-3, 13-16, 19, and 39, due to the patentable distinctions of claims 1-3, 13-16, 19, and 39 over the **Zauner** reference.

Zauner discloses a GaN single crystal substrate having a (0001) plane polished to obtain off-angle orientations of 0, 2, and 4 degrees toward the $\langle 10\bar{1}0 \rangle$ direction. (Zauner, abstract & pg. 437 Fig. 2). Zauner further teaches the mechano-chemical polishing of a GaN sample to a 4 degree misorientation approximately parallel to the $\langle \bar{1}\bar{1}20 \rangle$ direction (Zauner, pg. 438.)

By virtue of the amendments to independent claims 1, 22, 28, and 29, all of the pending claims now require, *inter alia*, a GaN (0001) surface offcut from the $\langle 0001 \rangle$ direction predominantly towards a direction selected from the group consisting of $\langle 10\bar{1}0 \rangle$ and $\langle 11\bar{2}0 \rangle$ directions, at an offcut angle in a range that is from about 5 to about 10 degrees. (Emphasis added.) The claimed offcut angle range of about 5 to about 10 degrees is **distinct from the offcut angle range of 0 to 4 degrees disclosed by Zauner**. For at least this reason, all of claims 1-3, 13-16, 19, and 39 (which have the "about 5 to about 10 degrees" offcut limitation) are allowable over Zauner, and withdrawal of the 103(a) rejection of these claims is respectfully requested.

CONCLUSION

Based on the foregoing, Applicants respectfully request the Examiner to: (1) withdraw the rejections of claims 1-3, 13-16, 18-21, and 39; and (2) rejoin non-elected amended method claims 22-38 herein.

The Office is hereby authorized to charge any fees that are properly payable for entry of this Response, to Deposit Account 08-3284 of Intellectual Property/Technology Law.

If any issues remain outstanding, incident to the formal allowance of the application, the Examiner is requested to contact the undersigned attorney at (919) 419-9350 to discuss same, in order that this application may be allowed and passed to issue at an early date.

Respectfully submitted,



Steven J. Hultquist
Reg. No. 28,021
Attorney for Applicants

INTELLECTUAL PROPERTY/
TECHNOLOGY LAW
P.O. Box 14329
Research Triangle Park, NC 27709
Telephone: (919) 419-9350
Fax: (919) 419-9354
Attorney Ref: 4241-687